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ANALOG DEVICES

Bridge Transducer Signal Conditioner

1B32

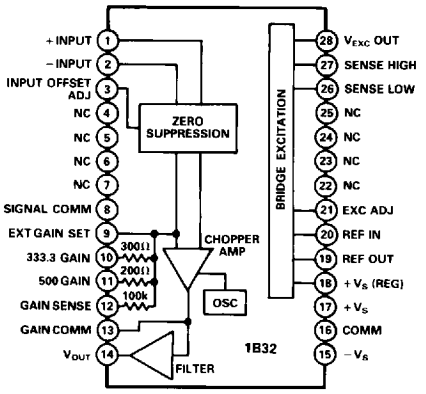
FEATURES

- Low Cost
- Complete Signal-Conditioning Solution
- Small Package: 28-Pin Double DIP
- Internal Thin-Film Gain Network
- High Accuracy
  - Low Input Offset Tempco: ±0.07μV/°C
  - Low Gain Tempco: ±2ppm/°C
  - Low Nonlinearity: ±0.005% max
  - High CMR: 140dB min (60Hz, G=1000V/V)
- Programmable Bridge Excitation: +4V to +15V
- Remote Sensing
- Low Pass Filter (f_C=4Hz)

APPLICATIONS

- Weigh Scales
- Instrumentation: Indicators, Recorders, Controllers
- Data Acquisition Systems
- Microcomputer Analog I/O

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

Model 1B32 is a precision, chopper-based, signal-conditioning component ideally suited for high-accuracy applications of load cells and bridge transducers. Packaged in a compact 28-pin plastic double DIP, the 1B32 takes advantage of hybrid technology for high reliability as well as higher channel density. Functionally, the signal conditioner consists of three basic parts: a high performance chopper-based amplifier, a low-pass filter and an adjustable transducer excitation source.

The chopper-based amplifier features extremely low input offset tempco of ±0.07μV/°C (RTI, G=500V/V) and excellent nonlinearity of ±0.005% max over its full gain range of 100 to 5000V/V. The 1B32 has a thin-film resistor network for pin-strapping the gain to 500V/V or 333.3V/V (for 2mV/V and 3mV/V load cells). The gain tempco for these fixed gains is a highly stable ±2ppm/°C. Additionally, the gain can be set to any value in the gain range with two external resistors. The amplifier also has a wide-range input referred zero suppression capability (±10V), which can easily be interfaced to a D/A converter. The bandwidth of the chopper is 4Hz at G=100V/V.

The integral three-pole, low-pass filter offers a 60dB/decade roll-off from 4Hz to reduce common-mode noise and improve system signal-to-noise ratio.

The 1B32's regulated transducer excitation stage features low output drift (±40ppm/°C typ) and can drive 120Ω or higher resistance load cells. The excitation is preset at +10V with other voltages between +4V and +15V programmable with external resistors. This section also has remote sensing capability to allow for lead-wire compensation in 6-wire load cells and other bridge configurations.

The 1B32 is fully specified over the industrial (−25°C to +85°C) temperature range.

DESIGN FEATURES AND USER BENEFITS

Pin-Strappable Gain: The internal resistor network can be pin-strapped for gains of 500V/V and 333.3V/V for 2mV/V and 3mV/V load cells. The tracking network guarantees a gain tempco of ±6ppm/°C max.

Custom Trimmable Network: For volume applications, the 1B32 can be supplied with a custom laser trimmed gain network. Contact factory for further information.

Wide Range Zero Suppression: The output can be offset by ±10V for nulling out a dead load or to do a tare adjustment.

Remote Sensing: Voltage drops across the excitation lead-wires are compensated by the regulated supply, making 6-wire load-cell interfacing straightforward.

Programmable Transducer Excitation: The excitation source is preset for +10V dc operation without external components. It is user-programmable for a +4V to +15V dc range (@ 100mA) to optimize transducer performance.

Low-Pass Filter: The three-pole active filter (f_C=4Hz) reduces 60Hz line noise and improves system signal-to-noise ratio.

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1B32—SPECIFICATIONS (typical @ +25°C and V_S = ±15V unless otherwise noted)

Model	1B32AN
GAIN	
Gain Range	100V/V to 5000V/V
Internal Gain Setting	333.3V/V and 500V/V
External Gain Equation	$G = 1 + \frac{R_F}{R_I}$; G ≥ 100
Gain Accuracy[1]	±0.1%
Gain Temperature Coefficient[2]	±2ppm/°C (±6ppm/°C max)
Gain Nonlinearity	±0.005% max
OFFSET VOLTAGES	
Total Offset Voltage, RTI	
Initial, @ +25°C, G = 1000V/V	±40μV
Warm-Up Drift, G = 1000V/V, 10 min	Within ±1μV of final value
vs. Temperature (−25°C to +85°C)	
G = 1000V/V	±0.07μV/°C (±0.2μV/°C max)
At Other Gains	$\pm\left(0.06 + \frac{15}{G}\right)\mu V/°C$
Output Offset Adjust Range	±10V
INPUT BIAS CURRENT	
Initial @25°C	±3nA
vs. Temperature (−25°C to +85°C)	±50pA/°C
INPUT DIFFERENCE CURRENT	
Initial @ +25°C	±3nA
vs. Temperature (−25°C to +85°C)	±10pA/°C
INPUT RESISTANCE	
Differential	100MΩ
Common Mode	100MΩ
INPUT VOLTAGE RANGE	
Linear Differential Input	±0.1V
Maximum Differential Input	+5V
CMV Input Range	0 to +7.5V
CMR, 1kΩ Source Imbalance[3]	
G = 100V/V to 5000V/V @ dc	86dB
G = 100V/V, @ 60Hz	120dB
G = 1000V/V, @ 60Hz	140dB min
INPUT NOISE	
Voltage, G = 1000V/V	
0.1Hz to 10Hz	1μV p-p
Current, G = 1000V/V	
0.1Hz to 10Hz	3pA p-p
RATED OUTPUT	
Voltage, 2kΩLoad, min	±10V
Current	±5mA
Impedance, dc to 2Hz, G = 100V/V	0.6Ω
Load Capacitance	500pF
Output Short Circuit Duration (to Ground)	Indefinite
DYNAMIC RESPONSE	
Small Signal Bandwidth	
−3dB Gain Accuracy, G = 100V/V	4Hz
G = 1000V/V	3.5Hz
Slew Rate	20V/sec
Full Power	0.5Hz
Settling Time, G = 100V/V, ±10V Output Step to ±0.1%	2sec
LOW PASS FILTER	
Number of Poles	3
Cutoff Frequency (−3dB Point)	4Hz
Roll-Off	60dB/decade

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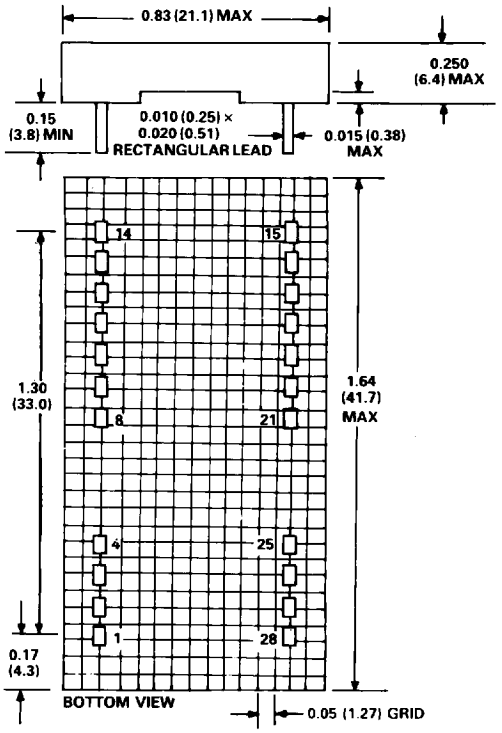
OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).



PIN DESIGNATIONS

PIN	FUNCTION	PIN	FUNCTION
1	+INPUT	15	$-V_S$
2	−INPUT	16	COMM
3	INPUT OFFSET ADJ	17	$+V_S$
4	NC	18	$+V_S$ REG
5	NC	19	REF OUT
6	NC	20	REF IN
7	NC	21	EXC ADJ
8	SIGNAL COMM	22	NC
9	EXT GAIN SET	23	NC
10	333.3 GAIN	24	NC
11	500 GAIN	25	NC
12	GAIN SENSE	26	SENSE LOW
13	GAIN COMM	27	SENSE HIGH
14	V_{OUT}	28	V_{EXC} OUT

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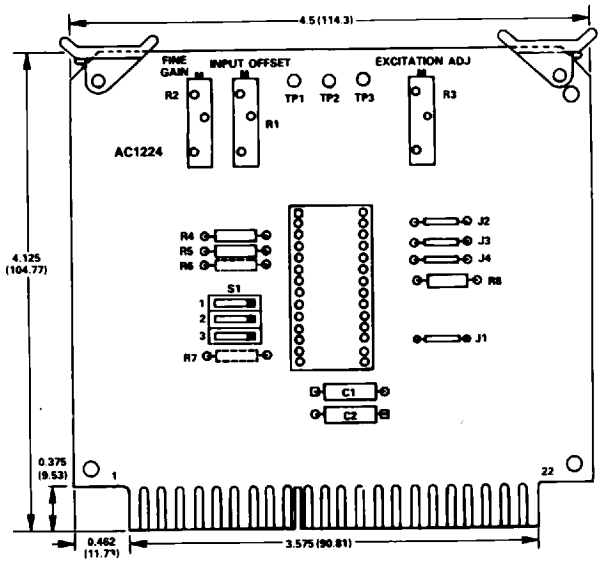
Model	1B32AN
BRIDGE EXCITATION	
Regulator Input Voltage Range	+9.5V to +28V
Output Voltage Range	+4V to +15V
Regulator Input/Output Voltage Differential	+3V to +24V
Output Current[4]	100mA max
Regulation, Output Voltage vs. Supply	±0.05%/V
Load Regulation, I_L = 1mA to 50mA	±0.1%
Output Voltage vs. Temperature (−25°C to +85°C)	±40ppm/°C
Output Noise, 0.1Hz to 10Hz[5]	300μV p-p
Reference Voltage (Internal)	+6.8V ±5%
Sense & Excitation Lead Resistance	10Ω max
POWER SUPPLY	
Voltage, Rated Performance	±15V dc
Voltage, Operating	±12V to ±18V dc
Current, Quiescent[6]	+4mA, −1mA
ENVIRONMENTAL	
Temperature Range	
Rated Performance	−25°C to +85°C
Operating	−40°C to +85°C
Storage	−40°C to +100°C
Relative Humidity	0 to 95%, Noncondensing, @ +60°C
CASE SIZE	0.83" × 1.64" × 0.25" (21.1 × 41.7 × 6.35mm) max

NOTES
[1]Using internal network for gain.
[2]For pin-strapped gain. The tempco of the individual thin-film resistors is ±50ppm/°C max.
[3]3V p-p 60Hz common-mode signal used in test setup.
[4]Derate 2mA/°C from +50°C.
[5]4.7μF capacitor from REF IN (Pin 20) to COMM.
[6]Excluding bridge excitation current and with no loading on the output.
Specifications subject to change without notice.

AC1224 Mounting Card



AC1224 GAIN SETTINGS VIA SWITCH S1

GAIN	S1–1	S1–2	S1–3
333	CLOSED	OPEN	CLOSED
500	OPEN	CLOSED	CLOSED
EXTERNAL	OPEN	OPEN	OPEN

AC1224 CONNECTOR DESIGNATIONS

PIN	FUNCTION	PIN	FUNCTION
T	V_{EXC} OUT	1	+INPUT
U	SENSE HIGH	2	−INPUT
V	SENSE LOW	12	V_{OUT}
X	REF OUT	19	$-V_S$
Y	REF IN	20	COMM
Z	EXC ADJ	21	$+V_S$
		22	$+V_S$ REG

The AC1224 mounting card is available for the 1B32. The AC1224 is an edge connector card with a socket for plugging in the 1B32. In addition it has provisions for switch selecting internal gains as well as installing gain resistors. Adjustment pots for offset, fine gain and excitation are also provided. The AC1224 comes with a Cinch 251-22-30-160 (or equivalent) edge connector.

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FUNCTIONAL DESCRIPTION

Model 1B32 is based on a switched capacitor, chopper based amplifier followed by an active filter and an adjustable voltage regulator section for excitation. The ultralow drift chopper samples the difference between the +INPUT and −INPUT at 190Hz. The signal is modulated, amplified and then demodulated. This stage introduces a pole with a 20dB/decade rolloff from 4Hz. The high-level signal is then filtered by a two-pole active filter with a 4Hz cutoff frequency to give a ±10V output. The clock signal for the chopper is generated by an on-board oscillator.

As shown in Figure 1, the gain can be pin-strapped by an internal resistor network. Standard gains of 333.3 and 500 can be achieved by this method with gain tempco of ±6ppm/°C max. Finally, the offset adjust of the amplifier is input referred, and requires a voltage input similar to the differential input voltage to implement wide range suppression.

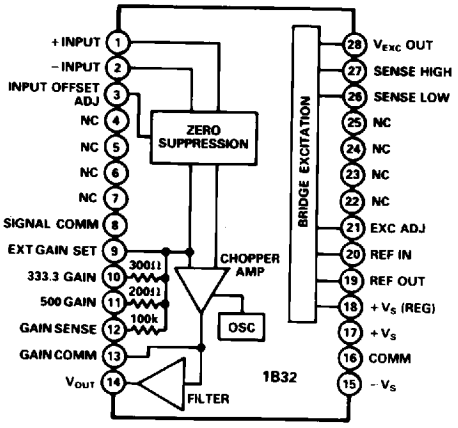

Figure 1. 1B32 Block Diagram and Pinout

The bridge excitation section is an adjustable output, regulated supply with an internally provided reference voltage (+6.8V). It is configured as a gain stage with the output preset at +10V. The excitation voltage is increased by connecting a resistor between Pins 21 and 26. Sense lines are provided to compensate for lead-wire resistance by bringing the leads into the feedback loop.

OPERATING INSTRUCTIONS

Ground Connections: Signal common (Pin 8) and power common (Pin 16) are not internally connected within the 1B32. These pins must be connected together externally or excessive current will be drawn.

Gain Setting: The differential gain of the 1B32 can be either pin-strapped or programmed externally with two resistors. The internal thin-film gain network (Figure 1) provides gains of 500 and 333.3 for standard load-cell sensitivities of 2mV/V and 3mV/V. This is achieved by connecting GAIN SENSE (Pin 12) to GAIN COMM (Pin 13) and grounding Pin 10 or Pin 11 (Figure 2). The gain tempco using the internal network is an excellent ±2ppm/°C typ (±6ppm/°C max).

To program the gain externally, two resistors are connected as shown in Figure 3. The gain equation is:

$$G = 1 + \frac{R_F}{R_I}$$

The gain-strapping Pins (10 and 11) and GAIN SENSE (Pin 12) are left unconnected, effectively floating the internal network.

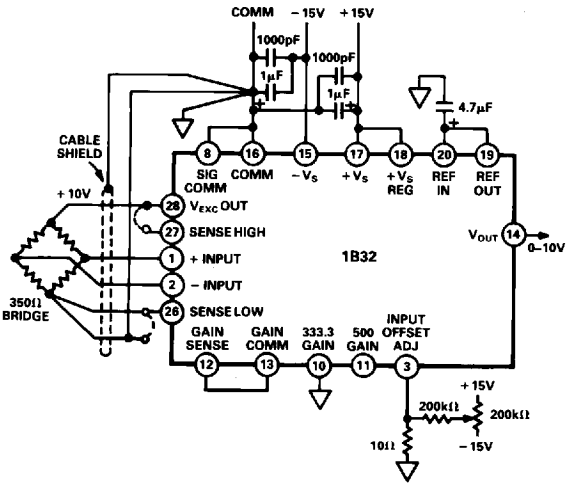

Figure 2. Internal Gain Strapping

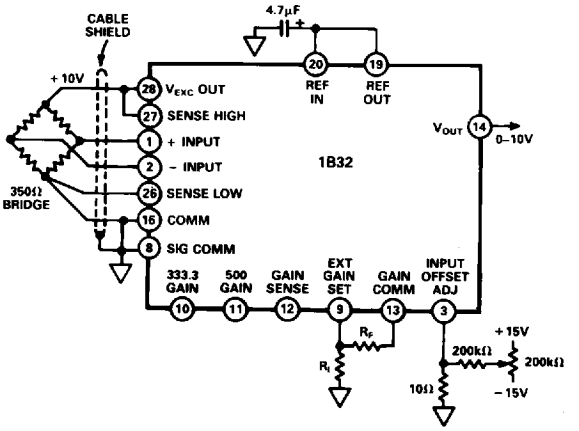

Figure 3. External Gain Setting

Offset Adjustment: The input-referred offset adjust has the same sensitivity as the inputs of the 1B32. The voltage level at INPUT OFFSET ADJ (Pin 3) is gained by the same factor as the input signal to provide a ±10V output adjust. Figure 2 shows an external network and potentiometer set up for a ±7.5mV span at the input, which gives a ±2.5V (7.5mV × 333.3) output adjust capability. Wider ranges can be chosen with the appropriate resistor and potentiometer values.

Note: If offset adjustment is not required, Pin 3 must be grounded.

Voltage Excitation Programming: The excitation voltage is preset to +10V. To increase V_{EXC} up to +15V a resistor must be connected between EXC ADJ and SENSE LOW (Pins 21 and 26) as shown in Figure 4.

The V_S (REG) input (Pin 18) must be raised to +18V to satisfy the +3V min input-output voltage differential of the regulator. Consult the Performance Characteristics section for safe operating conditions of the regulator. For a desired V_{EXC} the resistor value, R_{EXT}, is determined by the following equations:

$$R_T = \frac{10k\Omega \times V_{REF\ OUT}}{V_{EXC} - V_{REF\ OUT}} \quad ; \quad V_{REF\ OUT} = +6.8V$$

$$R_{EXT} = \frac{20k\Omega \times R_T}{20k\Omega - R_T}$$

The +10V to +15V range can be covered by a 20kΩ potentiometer between REF IN (Pin 20) and REF OUT (Pin 19). R_{EXT} of

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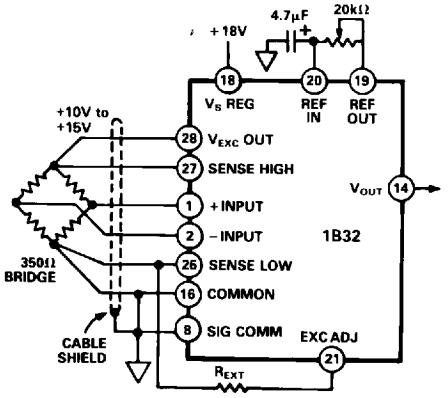

Figure 4. Constant Voltage Excitation: +10V to +15V Range.

200kΩ is recommended for fine adjustment at +10V excitation voltage.

Similarly to decrease V_{EXC} down to +4V, connect a 20kΩ potentiometer between Pins 19 and 20, as shown in Figure 5.

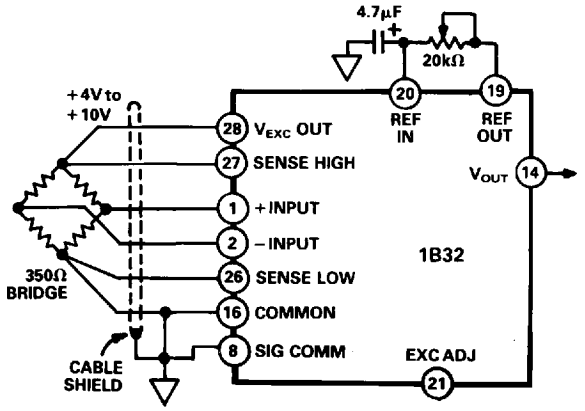

Figure 5. Constant Voltage Excitation: +4V to +10V Range.

A 4.7µF tantalum capacitor from REF IN (Pin 20) to COMMON (16) is recommended in all cases to lower the voltage noise at the reference input.

The remote sensing inputs should be connected to the transducer separately from the excitation leads or jumpered as shown in Figure 2. The resistance of the excitation and sense lines should not exceed 10Ω.

Power Supply: The V_S REG input (Pin 18) should be connected to $+V_S$ (Pin 17) even if the bridge excitation section is not used. Also the power supplies should be decoupled with 1µF tantalum and 1000pF ceramic capacitors as close to the 1B32 as possible (Figure 2).

Input Protection: The 1B32 differential inputs can be protected from accidental shorts to power line voltages (115V rms) by the circuit shown in Figure 6. The back-to-back diodes clamp the inputs to a maximum of ±12.5V and were selected for low leakage current. The 15kΩ resistors in series with the inputs will degrade the noise performance of the 1B32 to 4µV p-p (0.1Hz to 10Hz). When interfacing with six-wire load cells in harsh environments, input protection for the sense inputs is also recommended (Figure 6).

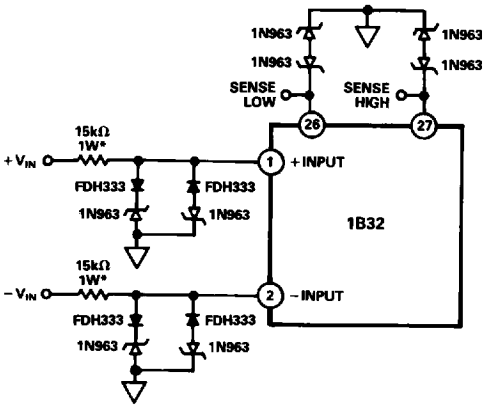

Figure 6. 115V Input Protection

PERFORMANCE CHARACTERISTICS

Input Offset Voltage Drift: The chopper front end of the 1B32 gives it excellent input offset stability. As shown in Figure 7, it typically exhibits drift of ±0.07µV/°C RTI at a gain of 1000V/V (±75µV/°C RTO). The measurement is two-point, and is taken at −25°C and +85°C, which covers the specified temperature range of the 1B32.

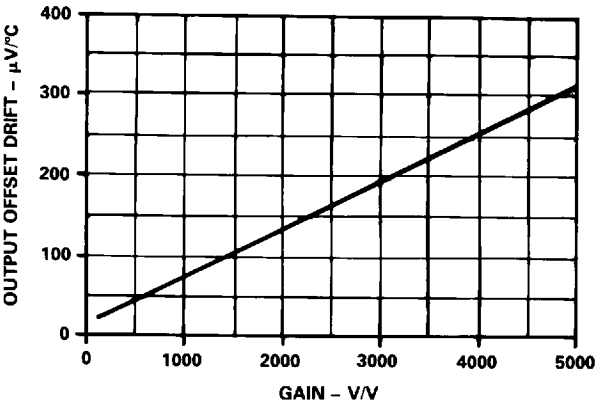

Figure 7. Total Output Offset Drift vs. Gain

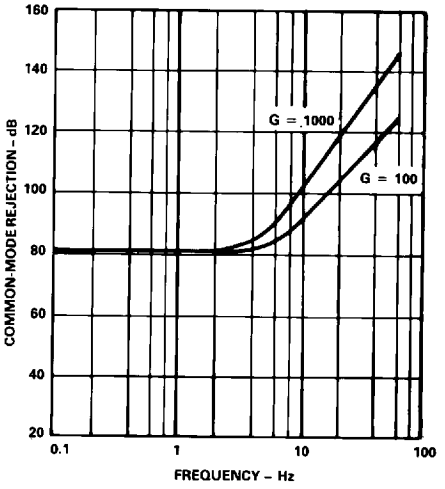

Figure 8. Common-Mode Rejection vs. Frequency

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Common-Mode Rejection: CMR as a function of frequency is shown in Figure 8. Test conditions are a 3V p-p common-mode signal and 1kΩ source imbalance. The CMR improves with increasing gain. Note that the 4Hz filter enhances the CMR performance above the corner frequency by attenuating the normal-mode signal at 60dB/decade.

Gain Nonlinearity and Noise: Gain Nonlinearity is specified as a percent of full-scale output, and for the 1B32 it is ±0.005% max over the full span. The chopper design also offers exceptional low-noise performance, with typical input noise of 1μV p-p in the 0.1Hz to 10Hz bandwidth (Figure 9).

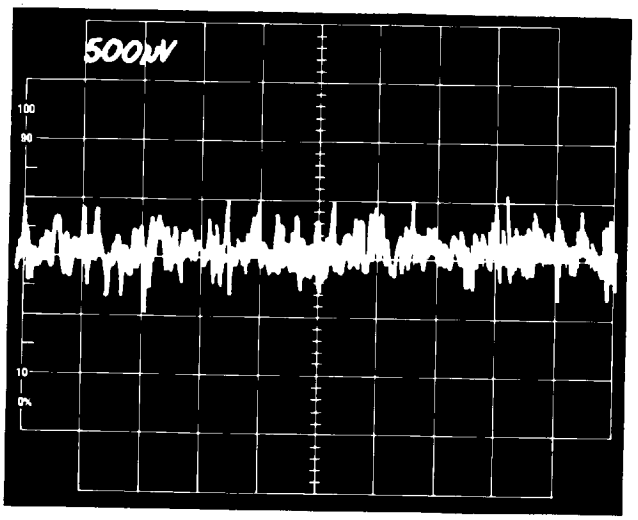

Figure 9. Voltage Noise, 0.1Hz to 10Hz, G = 1000

Low-Pass Filter: The 1B32 has three poles at 4Hz in its design. One is introduced in the amplifier, while the other two are provided by an active Butterworth filter following the amplifier. Total roll-off is 60dB/decade from 4Hz. The frequency response of the filter is shown in Figure 10.

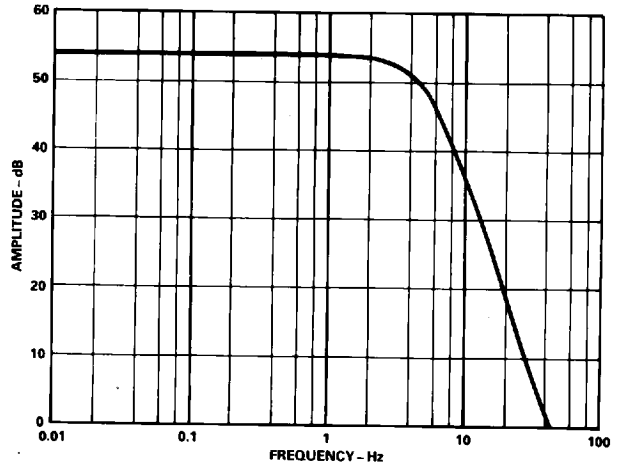

Figure 10. Filter Amplitude Response vs. Frequency, G = 500

Turn-On Drift: The 1B32 offset voltage typically stabilizes to within 1μV of its final value in 10 minutes (Figure 11). The test conditions are: 350Ω bridge with a +10V excitation and ambient temperature of +25°C.

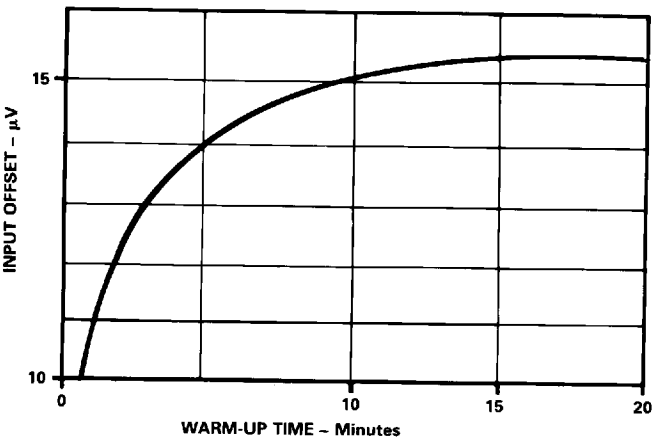

Figure 11. Offset Voltage RTI, Turn-On Drift

Bridge Excitation: The adjustable bridge excitation is specified over a wide regulator input voltage range (+9.5V to +28V). Maximum load current I_L as a function of regulator input-output differential voltage is shown in Figure 12. The maximum output current also depends on ambient temperature, and above +50°C a derating factor of 2mA/°C must be applied. The safe operating region for internal power dissipation vs. temperature is graphed in Figure 13.

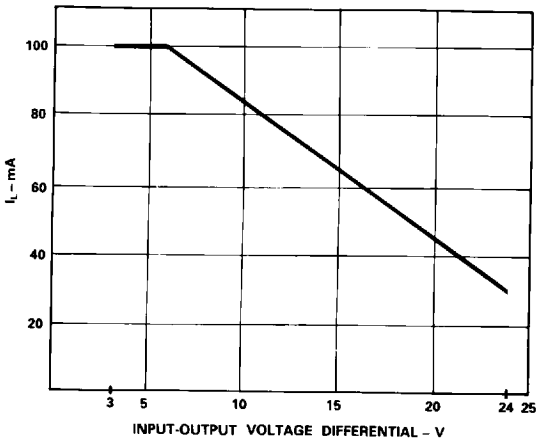

Figure 12. Excitation Source Load Current vs. Input-Output Voltage Differential, ≤25°C

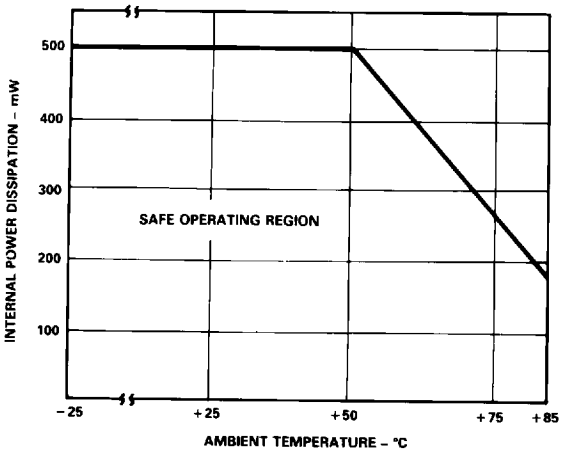

Figure 13. Excitation Source Internal Power Dissipation vs. Temperature

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APPLYING THE 1B32

Pressure Transducer Interface: A strain gage type pressure transducer (Dynisco 800 series) is interfaced to a 1B32 in Figure 14. Regulated excitation of +10V dc is provided for a 30mV full-scale output for a 0-10,000 psi range of the transducer. A shunt calibration resistor is built into the transducer for easy verification of the 80% point of its full-scale output. A typical shielding scheme to preserve the excellent performance characteristics of the 1B32 is also shown. To avoid ground loops, signal return and cable shield should be grounded only at one point.

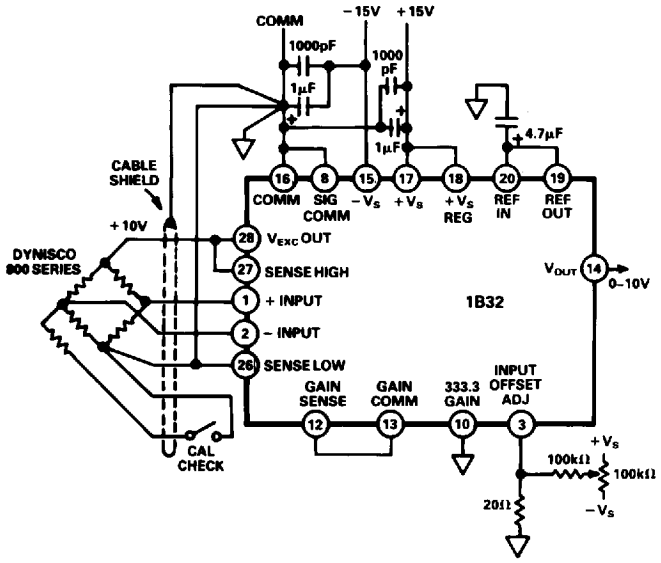

Figure 14. Pressure Transducer Interface

Pressure Transducer Data Acquisition System: A two module solution for microcomputer based data acquisition using a 1B32 and an AD1170 18-bit A/D converter is shown in Figure 15. A 3mV/V pressure transducer (e.g. Dynisco 800 series) is interfaced to a 1B32 configured with a gain of 333.3, to provide a 0 to 5V output. The regulated excitation is +5V, and is used as the reference input for the AD1170 to produce ratiometric operation. This configuration yields very high CMR enhanced by the 1B32 low pass filter and the integrating conversion scheme of the AD1170.

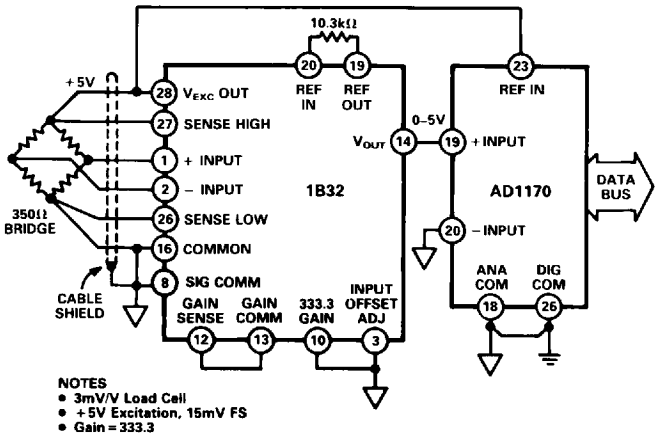

Figure 15. Auto-Calibrating Data Acquisition Using 1B32 and AD1170

In addition, fixed offsets caused by bridge imbalance can be nulled out by the AD1170 with a power-up initialization command from the microcomputer. The full-scale output of the 1B32 and transducer can be normalized to the AD1170 full scale through the electronic calibration command ECAL. Both the offset and full-scale correction data will then be stored in nonvolatile memory to eliminate the need for the trim process after each power-up. The AD1170 eliminates a potentiometer or software overhead which might otherwise be needed for these functions.

Multiple Load-Cells: For transducer configurations where the maximum load current of the 1B32 is not sufficient, a buffer and a power transistor such as a TIP31 can be used as shown in Figure 16. This approach will supply 300mA at +10V excitation over −25°C to +85°C temperature range. In a multiple 1B32 system an added advantage is that ratiometric operation can be preserved by using the excitation voltage as the reference for the system A/D converter.

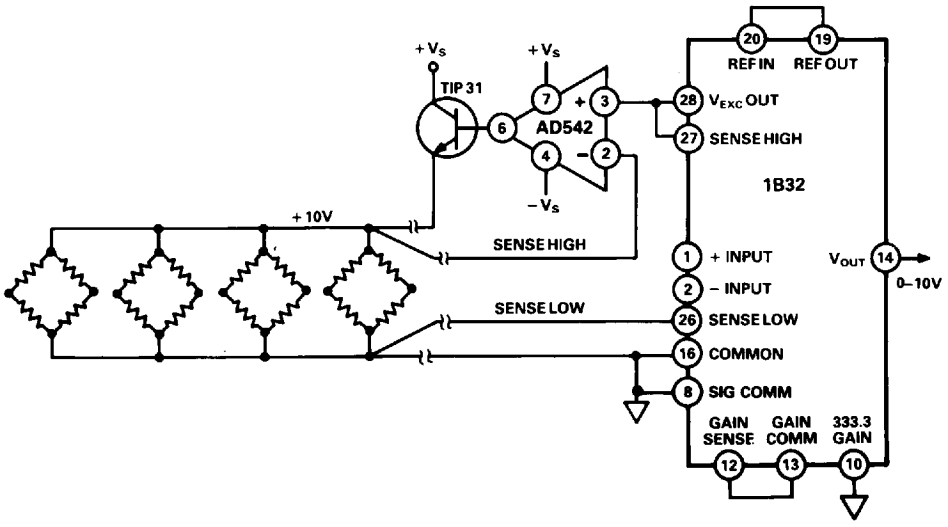

Figure 16. Multiple Load-Cell Application

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Mobile Transducer Applications: The small size and reliability of the 1B32 make it an excellent choice for mobile applications. Since the 1B32 requires bipolar supplies, a possible circuit to provide the negative voltage is shown in Figure 17. The CMOS TLC555 is powered by a +12V battery, and typically draws 360μA. The output is a square wave that is rectified by the diodes and filtered to provide a −9V supply. Excitation voltage should be equal to or less than +9V for adequate headroom for the 1B32 voltage regulator. Note that the 1B32 will operate with ±9V supplies as long as the excitation voltage and the output range are less than 5V.

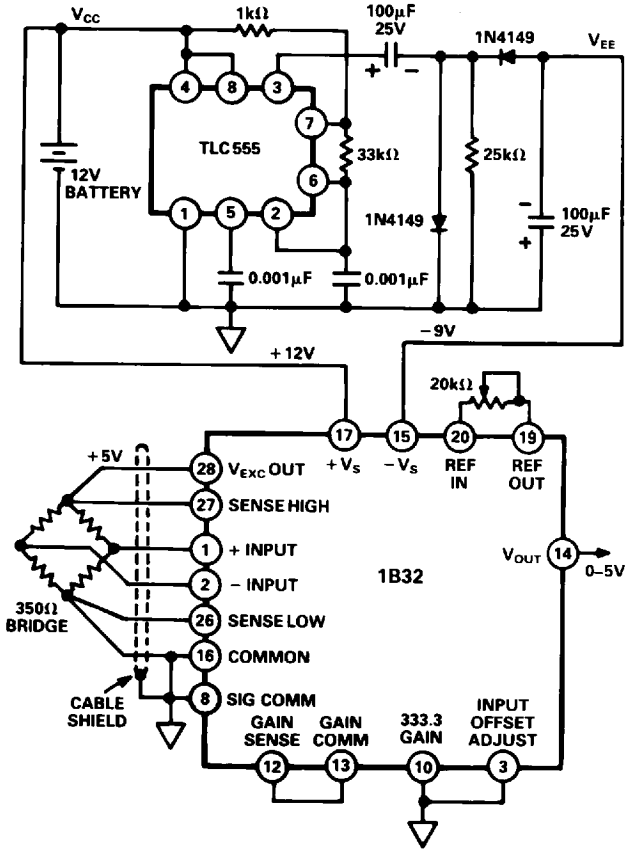

Figure 17. Negative Supply Generation for 1B32

Digital Output Offset Adjust: A 10-bit multiplying DAC such as the AD7533 can be used to control the output offset of the 1B32 as shown in Figure 18. The DAC is configured for unipolar operation with an AD OP-07 generating a voltage output. This 0-10V output is attenuated by R_1 and R_{SEL} and superposed on another fixed voltage derived from V_{EXC}. Thus the voltage at Pin 3 (INPUT OFFSET ADJUST) is insensitive to the tempco of the excitation voltage since it is also used as the reference of the DAC. For best performance R_1 and R_2 should track to ±5ppm/°C. As an example, a ±5V output adjustment can be obtained by using R_{SEL} = 200Ω for G = 500 and V_{EXC} = 10V.

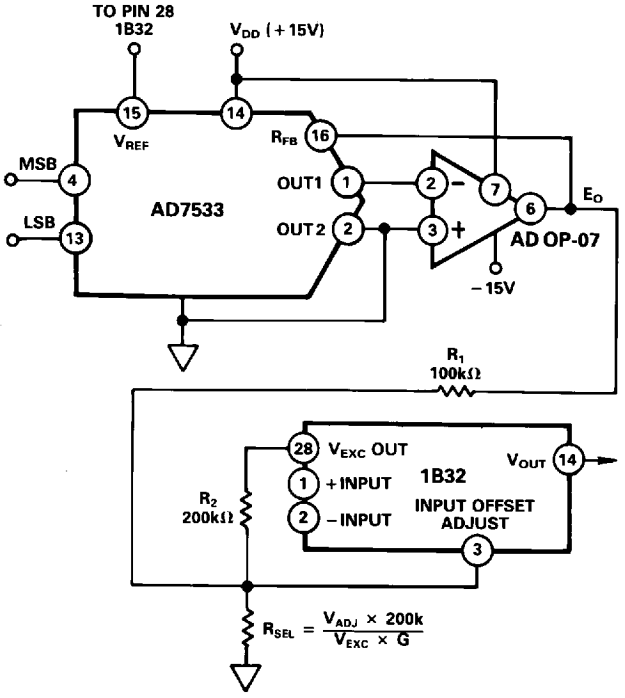

Figure 18. Output Offset Adjust Using a 10-Bit DAC

DIGITAL INPUT MSB LSB	ANALOG OUTPUT (E_O as shown in Figure 18)
1 1 1 1 1 1 1 1 1 1	$-V_{REF}\left(\frac{1023}{1024}\right)$
1 0 0 0 0 0 0 0 0 1	$-V_{REF}\left(\frac{513}{1024}\right)$
1 0 0 0 0 0 0 0 0 0	$-V_{REF}\left(\frac{512}{1024}\right)=\frac{V_{REF}}{2}$
0 1 1 1 1 1 1 1 1 1	$-V_{REF}\left(\frac{511}{1024}\right)$
0 0 0 0 0 0 0 0 0 1	$-V_{REF}\left(\frac{1}{1024}\right)$
0 0 0 0 0 0 0 0 0 0	$-V_{REF}\left(\frac{0}{1024}\right)=0$

Table I. Unipolar Binary Code Table

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